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DRAFT REGULATORY GUIDE

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DRAFT REGULATORY GUIDE DG-1197

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INSERVICE INSPECTION OF PRESTRESSED CONCRETE CONTAINMENT STRUCTURES WITH GROUTED TENDONS

A. INTRODUCTION

This guide describes an approach that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in developing an appropriate surveillance program for prestressed concrete containment structures with grouted tendons. The purpose of this guide is to provide recommendations for the inservice inspection (ISI) of prestressed concrete containments with grouted tendons .

The recommendations described in this guide are an approach that the NRC staff finds acceptable for satisfying the requirements of General Design Criterion (GDC) 53, "Provisions for Containment Testing and Inspection," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, *Code of Federal Regulations*, Part 50, "Domestic Licensing of Production and Utilization Facilities" (10 CFR Part 50) (Ref. 1). Among other specific requirements, GDC 53 requires that the containment be designed to permit (1) the appropriate periodic inspection of all important areas and (2) an appropriate surveillance program. Also 10 CFR § 50.55a mandates ISI for Class CC and Class MC containments in accordance with ASME Code, Section XI, Subsections IWL and IWE.

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with them is not required.

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number. This regulatory guide is a rule as designated in the Congressional Review Act (5 U.S.C. 801–808). However, the NRC has determined this regulatory guide is not a major rule as designated by the Congressional Review Act and has verified this determination with the OMB.

B. DISCUSSION

Background

The ISI of prestressed concrete containment structures with grouted tendons is necessary to verify, at specific intervals, that operating and environmental conditions have not reduced the safety margins provided in the design of containment structures. Since the issuance of Regulatory Guide 1.90, "Inservice Inspection of Prestressed Concrete Containment Structures with Grouted Tendons," Revision 1, in 1977, the industry and the NRC have been involved in research and testing to determine and evaluate the effectiveness of containment ISI programs. Containment tendon ISI guidance has been discussed during license submittals and reviews. Only two nuclear power plants in the United States have used grouted tendons: Three Mile Island Nuclear Station, Unit 2 (which is permanently shut down), and H.B. Robinson Steam Electric Plant (vertical tendons). However, in France, Belgium, Korea, Canada, and China, the use of grouted tendons in nuclear power plant containment has been more common (Refs. 2-8). In addition, at least one reactor design certification has proposed grouted tendons. For either grouted or ungrouted tendons, a prediction of the time-dependent behavior of concrete, particularly creep and shrinkage, is very important because of its potential impact on the prestress level that in turn affects the leak tightness and structural integrity of the containment (Ref. 2). The major concern in containment structures with grouted tendons is the possibility that corrosion of the tendon steel may occur and remain undetected and once grouted, the tendons cannot be retensioned or replaced.

The major factors influencing the occurrence of corrosion are (1) the susceptibility of the tendon steel to corrosion, (2) the degree of exposure of the tendon steel to a deleterious environment, (3) the extent of temperature variations, and (4) the quality of the grout and its installation. Licensees could significantly reduce the danger of widespread corrosion by following the recommendations in Regulatory Guide 1.107, "Qualifications for Cement Grouting for Prestressing Tendons in Containment Structures" (Ref. 3). However, the mechanism of corrosion in all conditions and situations is not fully understood. Because many parameters can influence the development of general corrosion or stress corrosion, an area of uncertainty with regard to the corrosion of tendon steel always exists; therefore, the licensee must monitor the structure in a manner that would reveal the existence of potentially detrimental corrosion. If bonded tendons are used, the applicant/licensee will have to demonstrate the adequate performance in maintaining the safety margin as afforded in the design of the containment. The inspection requirements in ASME section XI, subsection IWL (Ref. 4) for Class CC concrete containment are generally applicable to the containments with grouted tendons.

This guide outlines the recommendations for the ISI of containments that have grouted tendons of sizes with an ultimate strength of approximately 1,612 tons (14,339 kilonewtons) and that consist of parallel wires of several strands, which represents the current industry average. The detailed recommendations of the guide are not directly applicable to grouted tendon containments that have bar tendons. However, the licensee may develop a modified ISI program for grouted tendon containments with bar tendons using the principles provided in this guide. The NRC staff will review such programs on a case-by-case basis. This guide does not address the ISI of prestressing foundation anchors. If these anchors are used, the NRC staff will review the ISI program on a case-by-case basis. This guide does not address the ISI of the containment liner and penetrations.

One way of monitoring prestressed concrete structures is to ascertain the amount of prestress at certain strategically located sections in the structure. ISI reports and published papers (Refs. 2, 5, 6 and 24) show that available instrumentation (i.e., strain gauges, stress meters, vibrating wires, and strain meters) for concrete has remained in place and operable 65–90 percent of the time during a 10- to 25-year observation period. The literature also reported that the reliability of vibrating wire gauges was higher than that of strain gauges and meters. Given the variable reliability of the instrumentation, a multiple-strategy approach is recommended for monitoring the performance of prestressing tendons in prestressed concrete containments with grouted tendons.

Some have proposed real-time monitoring of the strength of the containment structure as an alternative monitoring means to ascertain the tendon prestress level (Refs. 7 and 8). Industry practice over the past 30 years and test programs conducted since 2000 on the durability and safety of grouted tendons (Refs. 8, 9, 10 and 24) have indicated that an ISI program should be based on a real-time, multiple-strategy approach (e.g., appropriate grout design and installation, instrumentation, periodic pressure test, and visual examination) for assuring the safe performance of the containment.

Another means used for monitoring the functionality of the containment structure would be to subject it to a pressure test and measure its performance under pressure.

This guide recommends the force monitoring of ungrouted test tendons and the performance assessment accomplished using either of two acceptable methods for inspecting containment structures with grouted tendons: (1) an ISI program based on monitoring the prestress level using instrumentation and on periodic pressure testing of the containment structure and (2) an ISI program based on pressure testing the containment structure as required by 10 CFR § 50.55a.

This guide outlines a detailed inspection program that is applicable to a sphere-torus dome containment with cylindrical walls that are up to 50 meters (165 feet) in diameter and that have an overall height up to 67 meters (220 feet) with three groups of tendons (i.e., hoop, vertical, and dome). This guide refers to such containment as the "reference containment."

For containments that differ from the reference containment or are under a controlled environment, the licensee may develop an ISI program using the concepts outlined in this guide and the guidelines provided in Appendix A.

The ISI program recommended in this guide consists of the following three elements:

1. the force monitoring of ungrouted test tendons,

2. periodic reading of instrumentation for determining the prestress level and deformations under pressure at preestablished sections (Alternative A) or deformations under pressure at preestablished sections (Alternative B), and

3. visual examination.

Force Monitoring of Ungrouted Test Tendons

Some tendons (otherwise identical) are left ungrouted and are protected from corrosion with grease. The changes observed in these tendons are not intended to represent the changes resulting from environmental or physical effects (with respect to corrosion) in the grouted tendons; instead, these test tendons are used as reference tendons to evaluate the extent of concrete creep, and shrinkage and the relaxation of the tendon steel.

The measurement of forces in ungrouted test tendons provides a quantitative means of verifying the design assumptions on the volumetric changes in concrete and the relaxation of prestressing steel. If some lift-off readings indicate values lower than the expected lower-bound values, the licensee should determine whether such values are caused by the corrosion of the wires of ungrouted tendons or by an underestimation of prestressing losses. These tendons may also serve as an investigative tool for assessing the structural condition of the concrete containment after certain incidents that could affect the containment.

Monitoring Alternatives for Grouted Tendons

Monitoring the Prestress Level and Pressure Testing (Alternative A)

After the application of prestress, the prestressing force in a tendon decreases because of the interaction of factors such as the following:

a. stress relaxation of the prestressing steel,

b. volumetric changes in concrete,

c. differential thermal expansion or contraction between the tendon, grout, and concrete, and

d. possible reduction in the cross-sectional area of the wires because of corrosion, including the possible fracture of the wires.

In this alternative, prestress level monitoring occurs at certain strategic locations in the containment. Thus, this alternative utilizes a sampling procedure in which an evaluation of the instrumentation readings may detect degradation in the vicinity of the instrumented section. However, if corrosion occurs at locations away from the instrumented sections, the corrosion would have to spread to the location within the instrument sensing area before the instrumentation readings would reflect the degradation. Therefore, the number of instrumentations and their locations play a critical role in assuring an effective monitoring process.

The licensee could use a combination of the following two methods which are acceptable to the NRC to monitor the prestressing force imparted to the structure by a grouted tendon system:

1. monitoring the tensile strains in the wires of a tendon; and

2. evaluating the prestress level at a section in the structure from readings of appropriately located strain gauges or strain or stress meters at the section (Refs. 5, 6, 11, 12, 13 and 24).

Method 1 above is useful for the direct monitoring of prestressing force in a tendon. However, this method requires careful attention during the installation of the strain-measuring instrumentation and the grouting of the tendons. An allowance for the relaxation of prestressing steel can be based on relaxation data for the prestressing steel used.

An evaluation of strain gauge and vibrating wire responses and stress meter readings requires a complete understanding of the contributing factors to the observed response (e.g., elastic shortening, shrinkage, creep, and thermal strain or stress components). Strain gauge readings will comprise contributions from elastic strains that correspond to the prestressing stress in concrete and strains that result from creep and shrinkage of concrete. Strains from the creep and shrinkage of concrete can vary between 1.5 and 2.5 times the elastic strains in concrete. However, the licensee can use specific methods, including the following, to isolate contributions from these effects:

a. Estimate average creep and shrinkage strains from the time-dependent losses measured on the ungrouted tendons.

b. Use stress meters at sections where strain gauges are used.

c. Use special strain meters that respond only to volumetric and temperature changes in concrete (Ref. 14).

A sufficient number of temperature sensors or thermocouples installed at the sections where the strain-measuring instrument is located can be useful in isolating the thermal effects. The raw instrument readings can be deceptive, and adjustments may be necessary to account for the calibration constants and temperature effects. The interpretation and evaluation of the results will be simplified if the instrument is located at sections away from structural discontinuities. Licensees should provide sufficient redundancy in the instrumentation to evaluate anomalous readings and to isolate a malfunctioning measurement gauge.

After appropriate methods and instruments are employed for measurement, one can analyze the measured data and arrive at an average stress and an average prestressing force at a section. Even though the predicted prestressing force that corresponds to a specific time may adequately consider the creep of concrete and the relaxation of prestressing steel, the likelihood is small that the measured value will compare well to the predicted value. Hence, the NRC staff recommends that an applicant establish a band of acceptable prestress levels similar to that illustrated in Figure 1. The staff also recommends that the bandwidth not exceed 8 percent (Ref. 15) of the initial prestressing force at a section after considering the loss resulting from elastic shortening, anchorage takeup, and friction. The 8-percent bandwidth would approximately correspond to between 40 and 70 percent of the total time-dependent losses, which staff has found to provide sufficient margin (Ref. 15).

Alternative A is based on the use of strain-measuring instruments and pressure testing. Many of these instruments must be initially built into the structure in such a manner that the licensee cannot replace or recalibrate them. As discussed in Section B of this guide, available instrumentation has remained operable 65 to 90 percent of the time over a 20-year observation period. Hence, the NRC staff recommends that the licensee also perform a pressure test at 1,3,5 and then not exceeding 10-year intervals (Ref. 16 and Figure 2). The section entitled, "Monitoring Deformation under Pressure (Alternative B)," below describes pressure testing.

Monitoring Deformation under Pressure (Alternative B)

Testing the containment under pressure and evaluating its elastic response are a proposed means of assessing the integrity of the containment.

The elastic response under pressure testing is primarily a function of the stiffness of the structure. Any significant decrease in the stiffness of the structure because of loss of prestress would result in the cracking of the structure under pressure. Because of the insensitive and indirect relationship between the prestressing force and the elastic response of the structure, licensees cannot use this method to establish the existing prestress level at various sections. However, the licensee could obtain a basis for evaluating the functionality of the structure by comparing the condition and deformation of the structure resulting from ISI pressure testing to those resulting from the pressure testing that it conducted during the initial structural integrity testing (ISIT) required by 10 CFR 50.55a. The NRC staff has accepted this method previously[1] on the condition that design of the containment has sufficient margin as required by the design criteria such that no cracking (or only slight cracking at the discontinuities) will occur under the required peak test pressure. Division 2, “Code for Concrete Reactor Vessels and Containments,” of Section III, “Rules for Construction of Nuclear Power Plant Components,” of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, also known as American Concrete Institute (ACI) Standard 359 (Ref. 17), allows an increase in the allowable stress in tensile reinforcement under a test condition. The NRC staff has accepted this allowance provided that it is only a one-time loading (i.e., during the ISIT). However, if the licensee performs such testing a number of times during the life of the containment structure, licensees should not use this allowance in order to avoid or minimize the gradual propagation of cracking during subsequent pressure tests.

The recommendations in this guide should be the basis for the deformation measurement locations during the pressure test. For a meaningful comparison of the deformations, the NRC staff recommends that the locations where the deformations are to be recorded have deformations greater than 1.5 millimeters (0.06 inches) under the calculated peak containment internal pressure associated with the design-basis accident and that these locations are approximately the same during the ISIT and the subsequent ISIs. Thus, these locations should be away from the areas of structural discontinuities.

If an analysis of the effects of parameters such as (i) normal losses in prestressing force, (ii) increase in the modulus of elasticity of concrete with age and (iii) differences in temperatures during various pressure tests indicate that they could affect the deformations of the selected locations, the evaluation that compares the deformations during various pressure tests needs to consider these parameters as well.

Visual Examination

The NRC staff recommends a visual examination of structurally critical areas consisting of the areas of structural discontinuities and the areas of heavy stress concentration (load points, support locations, connections, change of geometry, change of section etc.). Furthermore, the NRC staff recommends that the visual examination of concrete and tendon anchorage be performed in accordance with the provisions of ASME Code, Section XI, Subsection IWL, factoring in the considerations discussed in this guide. The ACI publication entitled, “Guide for Making a Condition Survey of Concrete in Service” (Ref. 18), provides acceptable guidance for reporting the condition of concrete, and the NRC staff suggests that the licensee use it as an applicable source for reporting the condition of examined areas.

Numerous examples exist on the use of the sonic pulse velocity technique to obtain information concerning the general quality of concrete. Based on operational experience and experimental data (Refs. 19–21), a pulse velocity of 4,500 meters/second (14,650 feet/second) or greater indicates good to excellent concrete quality. For normal weight concrete, a pulse velocity of 4,000 meters/second (12,940 feet/second) or lower indicates concrete of questionable quality. Thus, the technique provided in Ref. 22 can be used as part of the inspection of concrete containments when the visual examination reveals the presence of a high density of wide (greater than 0.25 millimeter (0.01 inch)) cracks or otherwise heavy degradation.

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[1] The NRC accepted this method for Three Mile Island Nuclear Station, Unit 2, which is permanently shut down.

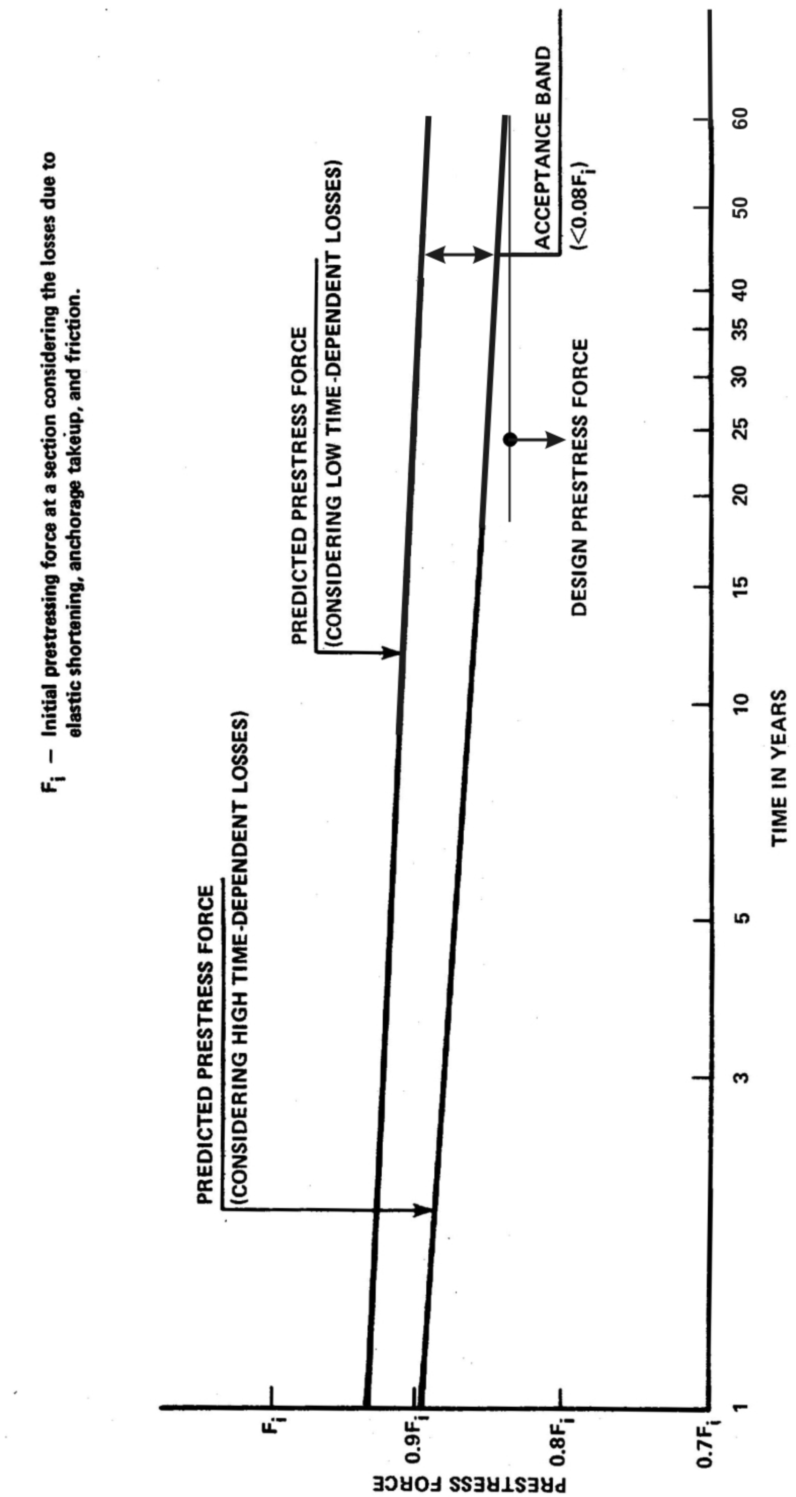


Figure 1 Typical band of acceptable prestress levels

C. REGULATORY POSITION

1. General

a. All prestressed concrete containment structures with grouted tendons should be subjected to an ISI program, consistent with the requirements of GDC 53 and 10 CFR § 50.55a. The specific guidelines provided here are for the reference containment described in Section B of this guide.

b. For containments that differ from the reference containment, the program described here should serve as the basis for developing a comparable ISI program. Appendix A to this guide gives guidelines for the development of such a program.

c. The ISI program should consist of the following elements:

    (1) force monitoring of ungrouted test tendons,

    (2) periodic reading of instrumentation for determining the prestress level and deformations under pressure at preestablished sections (Alternative A) or deformations under pressure at preestablished sections (Alternative B), and

    (3) visual examination.

d. The licensee should perform an ISI approximately 1, 3, and 5 years after the ISIT and every 5 years thereafter (Alternative B). However, when a licensee performs pressure testing as a part of an inspection for Alternative A, except for visual examinations, after 1, 3, and 5 year inspections, it may relax the frequency of inspections by pressure testing, but it should not exceed 10 years (see Figure 2).

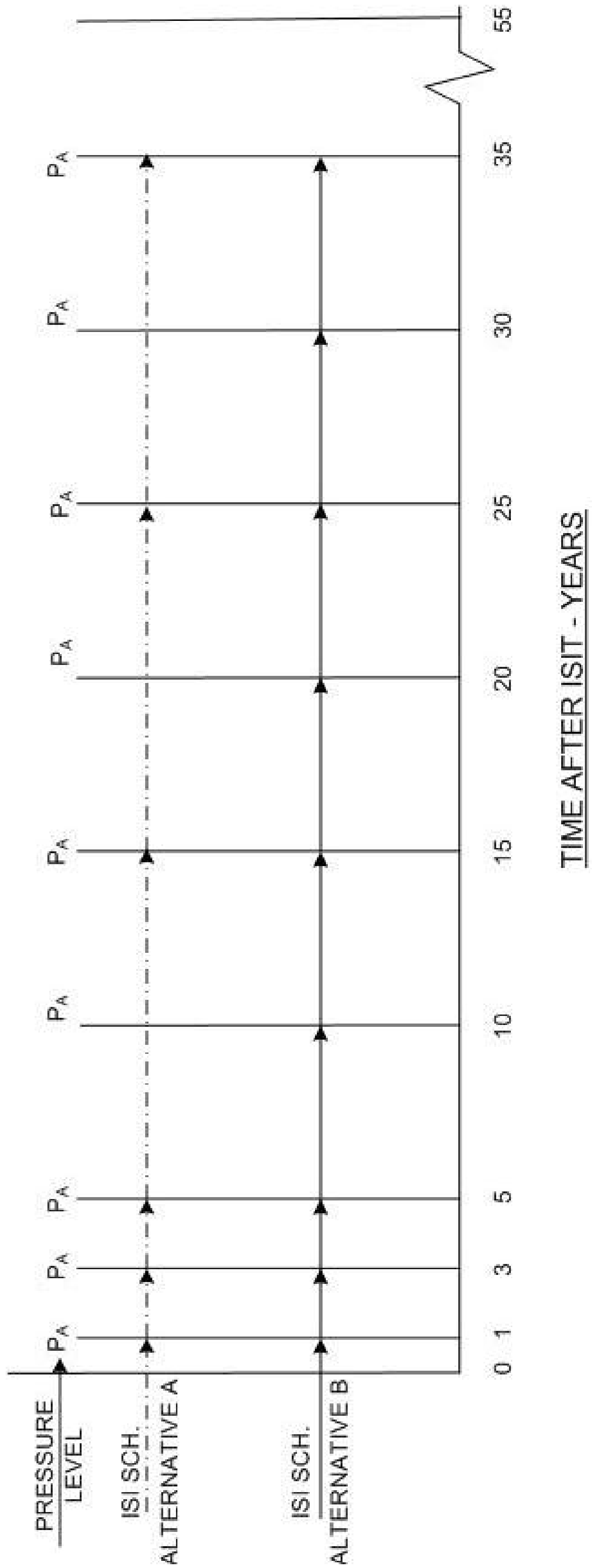
e. The licensee may substitute Alternative B for Alternative A if, at some point during the life of the structure, the inspection based on Alternative A does not provide satisfactory data (e.g., abnormal data suggesting that sensors are not working). The NRC staff will review the details of such a substitution on a case-by-case basis.

f. If the containment foundation is prestressed, the NRC staff will evaluate its proposed inspection program on a case-by-case basis.

2. Ungrouted Test Tendons

a. The following ungrouted test tendons should be installed in a representative manner:

    (1) three vertical tendons,
    (2) three hoop tendons, and
    (3) three dome tendons for the design using three 60-degree families of tendons.



KEY

P_A – Calculated Peak Internal Prerssure Associated with the Design Basis Accident

P_D – Containment Design Prerssure

ILRT – Integral Leak Rate Testing

ISIT – Initial Structural Integrity Testing

ISI – Inservice Inspection

Note:

1. Visual examination should follow ASME Section XI, IWL-2400.
2. During the ISIT, instrument reading may be taken at both the test pressure ($1.15P_D$) as well as P_A. P_A readings may be also taken during the preoperational ILRT. These PA readings may provide a reference for future data comparison.

Figure 2 Schedule for ISIs (Alternative A and Alternative B)

b. The ungrouted test tendons and their anchorage hardware should be identical to the grouted tendons and their hardware.

c. The ungrouted test tendons should be subjected to force measurement by lift-off testing or an equivalent test to assess the effects of concrete shrinkage and creep and the relaxation of the tendon steel. The licensee should evaluate these data in conjunction with the overall structural condition of the containment evident from the other direct examinations.

3. Monitoring Alternatives for Grouted Tendons

3.1 <u>Instrumentation for Monitoring the Prestress Level and Pressure Testing (Alternative A)</u>

3.1.1 *Installation*

a. The prestressed cylindrical wall and dome should be instrumented for stress/strain measurements. The licensee should select the instrument types, locations, and quantities to provide the best representation of the prestress level in the structure. The licensee should also install a sufficient number of temperature sensors or thermocouples to isolate and evaluate the effects of variations in temperature gradients on the instrument readings. Redundancy of the embedded instrumentation should be based on a conservative estimate of the probability of a malfunction of the instrumentation to be installed.

b. The licensee should arrange and distribute the instruments in the concrete in such a manner as to permit the evaluation of the prestressing levels and should locate them as follows:

(1) at horizontal planes to measure the hoop prestressing levels,
(2) along vertical tendons to measure vertical prestress levels, and
(3) along dome tendons for the design using three families of 60-degree tendons.

Figure 3 delineates the typical planes and tendons.

c. At the horizontal, vertical, and dome sections, the licensee should monitor the prestress levels using a combination of various types of instruments to measure stress, strain, temperature, pressure, and other parameters in concrete, rebar, and tendons. For a containment that is similar to the reference containment, industry has used approximately 250 to 300 instruments (Ref. 5).

3.1.2 *Characteristics*

a. Instruments used to determine the concrete prestress level should have the capability of being effectively used over the life of the containment structure within specified operational limits under the following conditions, unless otherwise defined by the designer and approved by the NRC staff:

(1) humidity: 0 to 100 percent,

(2) temperature: -18 degrees Celsius (0 degrees Fahrenheit) to 93 degrees Celsius (200 degrees Fahrenheit), and

(3) cyclic loading: 500 cycles of 4.2 megapascals (600 pounds per square inch) stress variation in compression.

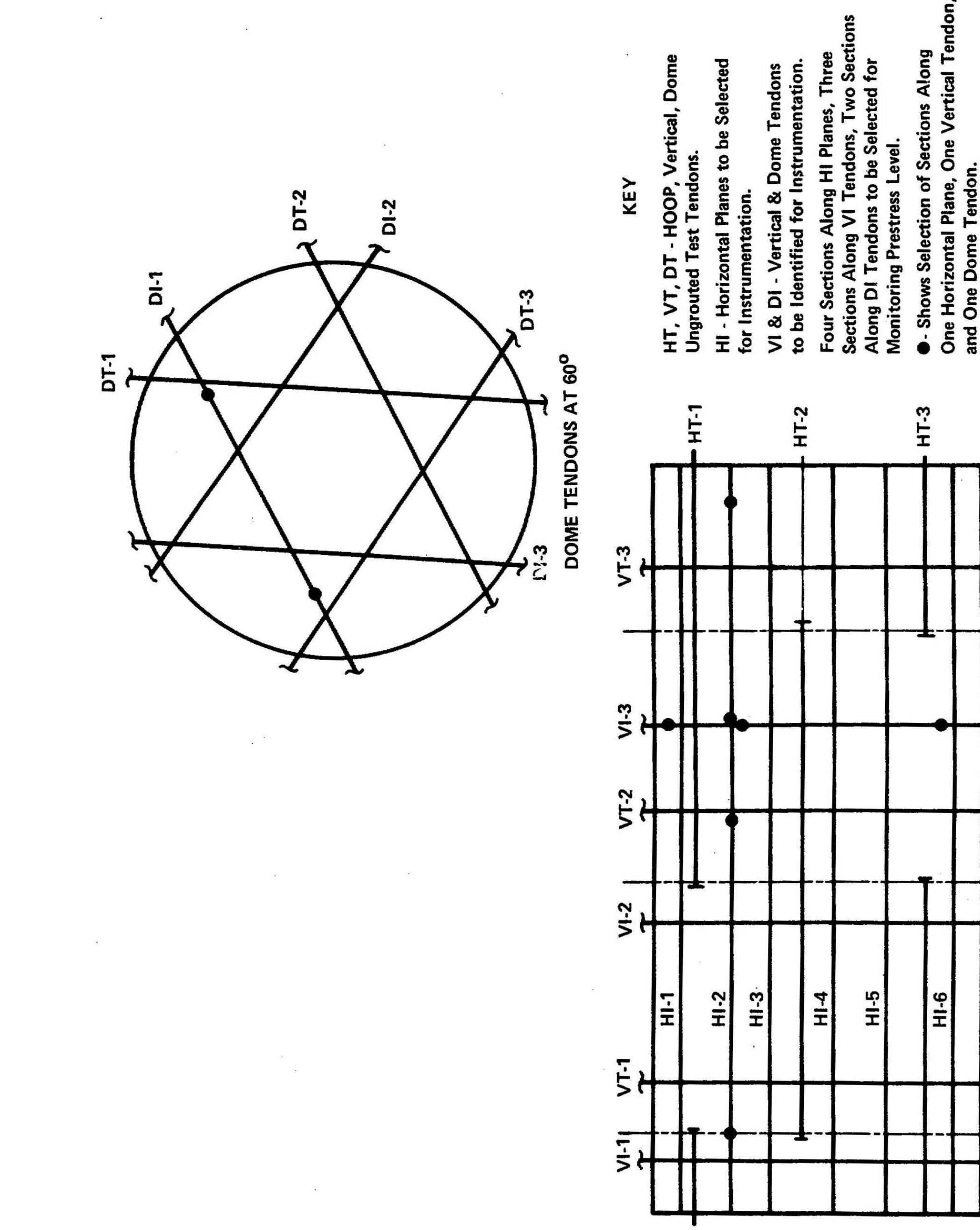


Figure 3 Containment diagram showing typical locations of test tendons and instrumentation

b. The licensee should protect the instruments against adverse effects of the expected environment (e.g., electrolytic attack, including the effects of stray electric currents of a magnitude that may be encountered at the particular site and structure). These instruments should be protected from potential temperature extremes while the containment is under construction.

c. The licensee should specify the sensitivity of the strain gauges. The licensee should account for the drift or the stability, under the conditions in Regulatory Positions a and b above, in the specified limits or should recalibrate the gauges in service.

d. The stress meters should be able to measure compressive stresses up to 17.2 megapascals (2,500 pounds per square inch).

3.1.3 *Monitoring Instrumentation Operability*

a. After the installation of the instrument, the licensee should collect the readings of all embedded instruments continuously. The licensee should interpret the readings every 2 months until it performs the ISIT. The response of the instrumentation during prestressing and pressure testing (ISIT) should be used to confirm its operability. After the ISIT, the licensee should continue monitoring the instrumentation and interpret the readings every 2 months to reconfirm its operability until the first ISI. Thereafter, it may reduce the interpretation frequency to once every 6 months, unless local conditions or special circumstances dictate more frequent monitoring. The time interval for data interpretation is unchanged from earlier revision of this guide. The operability of the instrument should also be confirmed during subsequent pressure tests. If the licensee obtains anomalous readings, it should determine the reason for such readings. If the licensee determines that the anomalous readings result from defective gauges, it should justify the basis for such a determination.

b. To provide an initial baseline, during the ISIT, instrumentation readings should be recorded corresponding to both the test pressure ($1.15P_D$) as well as P_A. The instrument readings corresponding to P_A may also be recorded during the preoperational ILRT.

c.

3.1.4 *Monitoring Deformation under Pressure*

a. Monitoring deformation under pressure is the same as Alternative B but at a different frequency. After inspections at 1, 3, and 5 year intervals, a licensee may relax the frequency of pressure testing, but it should not exceed 10 years.

3.2 Monitoring Deformation under Pressure (Alternative B)

3.2.1 *Pressurization*

During the pressure tests, the containment structure should be subjected to a maximum internal pressure equal to the calculated peak internal pressure associated with the postulated design-basis accident, P_A (Figure 2).

3.2.2 *Instruments and Deformations*

a. The licensee should install instruments similar to those used during the ISIT before pressure testing of the structure to obtain a measurement of the overall deformations at the selected points.

b. An error band should specify the limit of the accuracy of the readings of the instruments to be used to obtain a meaningful comparison of the deformations measured during the ISIT and ISI.

c. The licensee should determine the locations for mounting the instruments used to measure the radial displacements in six horizontal planes in the cylindrical portion of the shell with a minimum of four locations in each plane (see Figure 3).

d. The licensee should determine the locations for mounting the instruments used to measure the vertical (or radial) displacements as follows:

    (1) at the top of the cylinder relative to the base at a minimum of four approximately equally spaced azimuths or

    (2) at the apex of the dome and one intermediate location between the apex and the springline on at least three equally spaced azimuths.

e. The intermediate pressure levels at which the deformations at the selected locations will be measured should correspond to those for the ISIT.

f. To provide an initial baseline, during the ISIT, instrumentation readings for deformation should be recorded corresponding to both the test pressure ($1.15P_D$) as well as P_A. The instrument readings corresponding to P_A may also be recorded during the preoperational ILRT.

4. Visual Examination

4.1 Structurally Critical Areas

a. The licensee should perform a visual examination of the following exposed, structurally critical areas:

    (1) areas at structural discontinuities (e.g., junction of the dome and cylindrical wall or the wall and base mat),

    (2) areas around large penetrations (e.g., equipment hatch and air locks) or a cluster of small penetrations,

    (3) local areas around penetrations that transfer high loads to the containment structure (e.g., around high-energy fluid system lines),

    (4) other areas where heavy loads are transferred to the containment structure (e.g., crane supports), and

    (5) areas of high predicted stresses under the critical design-basis load combination(s).

b. During all pressure tests, the licensee should conduct a visual examination of structurally critical areas as identified when the containment is at its maximum test pressure, even if it has conducted visual examinations of these areas at other times.

4.2 <u>Anchorage Assemblies</u>

a. The licensee should visually examine exposed portions of the tendon anchorage assembly hardware or the permanent protection thereon (whether it be concrete, grout, or a steel cap) by sampling in the following manner:

   (1) a minimum of six dome tendons, two of which are located in each 60-degree group (three families of tendons), randomly distributed to provide representative sampling,

   (2) a minimum of five vertical tendons randomly, but representatively, distributed, and

   (3) a minimum of ten hoop tendons randomly, but representatively, distributed.

b. For each succeeding examination, the licensee should select tendon anchorage areas that it will examine on a random, but representative basis so that the sample group will change each time.

c. The ISI program should define the defects that the inspector should look for during his or her visual examination of the exposed anchor hardware and the protection medium and should establish the corresponding limits and tolerances. The licensee should pay special attention to the concrete that supports the anchor assemblies and should analyze any observed crack patterns at these locations.

d. The visual examination should be performed in accordance with the applicable provisions of ASME Section XI, Subsection IWL, factoring in the consideration in paragraphs 4.1 and 4.2 above.

5. Reportable Conditions

5.1 <u>Inspection Using Alternative A</u>

a. The licensee should consider a condition reportable in which the average prestress force along any tendon falls below the acceptable band (see Figure 1).

b. The licensee should consider a condition reportable in which the prestress force determined at any section falls below the design prestress force.

c. The licensee should consider a condition reportable in which the deformation measured under the maximum test pressure at any location exceeds 5 percent of that measured during the ISIT under the same pressure. The 5 percent allowance is in excess of acceptable instrument tolerance.

5.2 <u>Inspection Using Alternative B</u>

a. The licensee should consider a condition reportable in which the deformation measured under the maximum test pressure at any location exceeds 5 percent of that measured during the ISIT under the same pressure. The 5 percent allowance is in excess of acceptable instrument tolerance.

5.3 Reportable Conditions for Visual Examinations

a. The licensee should consider a condition reportable in which any crack pattern observed at the structurally critical areas indicates a significant decrease in the spacing or an increase in the widths of cracks compared to those observed during the ISIT at zero pressure after depressurization.

b. The licensee should consider a condition reportable in which the visual examination of the anchor hardware indicates obvious movement or degradation of the anchor hardware.

c. The licensee should consider a condition reportable in which the anchor hardware is covered by permanent protection and the visual examination reveals a degradation (e.g., extensive cracks or corrosion stains) that could potentially challenge the integrity and effectiveness of the protection medium.

5.4 Reportable Conditions for Ungrouted Test Tendons

a. The licensee should consider a condition reportable in which the force monitoring (by lift-off or equivalent test) of ungrouted test tendons indicates a prestress force below the acceptable band (see Figure 1).

6. Reporting to the Commission

a. The reportable conditions of Regulatory Position 5 could indicate a possible abnormal degradation of the containment structure (a boundary designed to contain radioactive materials). Any such condition should be reported to the Commission in accordance with 10 CFR 50.36(c)(5).

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[2] may use this regulatory guide, as well as the NRC's plans for using it. In addition, it describes the NRC staff's compliance with 10 CFR 50.109, "Backfitting," and any applicable finality provisions in 10 CFR Part 52.

Use by Applicants and Licensees

Applicants and licensees may voluntarily use the information in this regulatory guide (1) to develop applications for initial licenses, amendments to licenses, or other requests for NRC regulatory approval (e.g., exemptions), (2) for actions that do not require prior NRC review and approval (e.g., changes to a facility design under 10 CFR 50.59, "Changes, Tests and Experiments"), or (3) to resolve regulatory or inspection issues (e.g., by committing to comply with the provisions in the regulatory guide).

Current licensees may continue to use the guidance, such as a previous version of this regulatory guide, that the staff found acceptable for complying with specific portions of the regulations as part of their license approval process.

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2 In this section, "licensees" include applicants for standard design certifications under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 23).

A licensee who believes that the NRC staff is inappropriately imposing this regulatory guide in response to a request for a license amendment or a change to a previously issued NRC regulatory approval may file a backfitting appeal with the NRC in accordance with applicable procedures.

Use by NRC Staff

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this regulatory guide. It does not expect any existing licensee to use or commit to using the guidance in this regulatory guide in the absence of a licensee-initiated change to its licensing basis. The NRC staff does not plan to ask licensees to voluntarily adopt this regulatory guide to resolve a generic regulatory issue, nor does it expect to initiate, without further backfit consideration, regulatory action that would require the use of this regulatory guide (e.g. issuance of an order, generic communication, or rule requiring the use of the regulatory guide, or requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this regulatory guide).

During inspections of specific facilities, the staff may suggest or recommend that licensees consider various actions consistent with staff positions in this regulatory guide as one acceptable means of meeting underlying NRC regulatory requirements. Such suggestions and recommendations would not ordinarily be considered backfitting, even if prior versions of this regulatory guide are part of the licensing basis of the facility with respect to the subject matter of the inspection. However, unless this regulatory guide is part of the licensing basis for a plant, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this regulatory guide constitutes a violation.

If an existing licensee seeks a license amendment or change to an existing regulatory approval, and the staff's consideration of the request involves a regulatory issue that is directly relevant to this regulatory guide, and if the specific subject matter of the new or revised guidance is an essential consideration in the NRC staff's determination of the acceptability of the licensee's request, the staff may require the licensee to use this regulatory guide as a prerequisite for NRC approval. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

Conclusion

While current licensees may voluntarily use this regulatory guide, this regulatory guide is not being imposed upon current licensees. In addition, issuance of this Regulatory Guide is in conformance with all applicable internal NRC policies and procedures governing backfitting. Accordingly, the issuance of this regulatory guide is not considered backfitting, as defined in 10 CFR 50.109(a)(1), nor is it deemed to be in conflict with any of the issue finality provisions in 10 CFR Part 52.

GLOSSARY

vibrating wire strain gauge—Devices whose natural period is modified in case of concrete deformation (contraction or dilation) (Ref. 5).

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APPENDIX A

GUIDELINES FOR DEVELOPING THE INSERVICE INSPECTION PROGRAM FOR CONTAINMENTS (OTHER THAN REFERENCE CONTAINMENT) WITH GROUTED TENDONS

A-1. Ungrouted Tendons

Three ungrouted tendons should be provided in each type of tendon. The tendon type is defined by its geometry and position in the containment.

A-2. Instrumentation and the Monitoring of Deformations under Pressure (Alternative A)

The following criteria should be used to determine the number of sections (N) to be monitored for each group of tendons:

$$N = \frac{\text{Actual Area Prestressed by a Group of Tendons}}{K \times \text{Area Monitored by a Set of Instruments at a Section (determined as } S \times L)},$$

where

S = spacing of tendons in feet (meters),

L = length of a tendon monitored by a set of instruments (may be considered as 12 feet (3.66 meters)), and

K is determined as follows:

a. For containments that are under an uncontrolled environment and that have continuous tendon curvature, $K \leq 100$.

b. For containments that are under an uncontrolled environment and that have essentially straight tendons, $K \leq 160$.

c. For containments that are under a controlled environment and that have either straight or curved tendons, $K \leq 200$.

For periodic pressure testing of the containment, follow the guideline provided in Section A-3.

A-3. Monitoring Deformations under Pressure (Alternative B)

The number of locations (N) to be selected for measuring the deformations under pressure should be determined as follows:

a. For radial deformations of the cylinder,

$$N = \frac{\text{Surface Area of Cylinder in Square Feet (Square Meters)}}{2{,}700\ (250)},$$

but not less than 12.

b. For vertical deformations of the cylinder, N = 4.

c. For radial or vertical deformations of the dome,

$$N = \frac{\text{Surface Area of Dome in Square Feet (Square Meters)}}{2{,}700\ (250)},$$

but not less than 4.